



US006533905B2

(12) **United States Patent**  
**Johnson et al.**

(10) Patent No.: **US 6,533,905 B2**  
(45) Date of Patent: **Mar. 18, 2003**

(54) **METHOD FOR SPUTTERING TINI  
SHAPE-MEMORY ALLOYS**

(75) Inventors: **A. David Johnson, San Leandro, CA (US); Valery V. Martynov, San Francisco, CA (US); Vikas Gupta, San Leandro, CA (US); Arani Bose, New York City, NY (US)**

(73) Assignees: **TiNi Alloy Company, San Leandro, CA (US); Smart Therapeutics, Inc., San Leandro, CA (US)**

(\*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/768,700**

(22) Filed: **Jan. 24, 2001**

(65) **Prior Publication Data**

US 2001/0039449 A1 Nov. 8, 2001

**Related U.S. Application Data**

(60) Provisional application No. 60/177,881, filed on Jan. 24, 2000, and provisional application No. 60/211,352, filed on Jan. 30, 2000.

(51) Int. Cl.<sup>7</sup> ..... **C23C 14/34**  
(52) U.S. Cl. .... **204/192.15**  
(58) Field of Search ..... **204/192.12, 192.15; 216/41, 96, 100**

(56) **References Cited**

**U.S. PATENT DOCUMENTS**

3,668,131 A \* 6/1972 Banush et al. .... 216/103  
3,991,898 A \* 11/1976 Hanson et al. .... 220/592.2  
5,061,914 A 10/1991 Busch et al.  
5,474,563 A \* 12/1995 Myler et al. .... 606/108  
5,772,864 A \* 6/1998 Moller et al. .... 205/73  
6,096,175 A \* 8/2000 Roth ..... 204/192.15  
6,107,004 A \* 8/2000 Donadio, III ..... 430/320  
6,224,626 B1 \* 5/2001 Steinke ..... 623/1.16  
6,379,383 B1 \* 4/2002 Palmaz et al. .... 623/1.49  
2001/0032013 A1 \* 10/2001 Marton ..... 623/1.15

**FOREIGN PATENT DOCUMENTS**

WO WO 99/62432 12/1999

**OTHER PUBLICATIONS**

J Busch et al. "Shape-memory properties in Ni-Ti sputter-deposited film", Dec. 15, 1990, Journal of Applied Physics vol. 68, Issue 12 (abstract only).\*

S. Miyazaki et al. "Martensitic Transformations in sputter-deposited Ti-Ni-Cu shape memory alloy thin films", 1996, Thin Solid Films, 281-282, Elsevier, pp. 364-367.\*

Dario, P. and Montesi, M.C., "Shape Memory Alloy Microactuators for Minimally Invasive Surgery", *Proceedings of SMST-94 Conference*, pp. 427-433, Pacific Grove CA, (1994).

Johnson, A.D., "Vacuum-Deposited TiNi Shape Memory Film: Characterization and Applications in Microdevices", *J. Micromech. Microeng.* 1:34-41, (1991).

Kruelevitch, P. et al., "Thin Film Shape Memory Alloy Microactuators", *J. Micromech. Microeng.* 5(4):270-282, (1996).

Schetky, L.M., "Shape-Memory Alloys", *Scientific American* 74-82, (1979).

\* cited by examiner

Primary Examiner—Patrick Ryan

Assistant Examiner—Gregg Cantelmo

(74) Attorney, Agent, or Firm—Vidas, Arrett & Steinkraus

(57) **ABSTRACT**

A thin film device, such as an intravascular stent, is disclosed. The device is formed of a seamless expanse of thin-film (i) formed of a sputtered nitinol shape memory alloy, defining, in an austenitic state, an open, interior volume, having a thickness between 0.5-50 microns, having an austenite finish temperature  $A_f$  below 37° C.; and demonstrating a stress/strain recovery greater than 3% at 37° C. The expanse can be deformed into a substantially compacted configuration in a martensitic state, and assumes, in its austenitic state, a shape defining such open, interior volume. Also disclosed is a sputtering method for forming the device.

11 Claims, 4 Drawing Sheets